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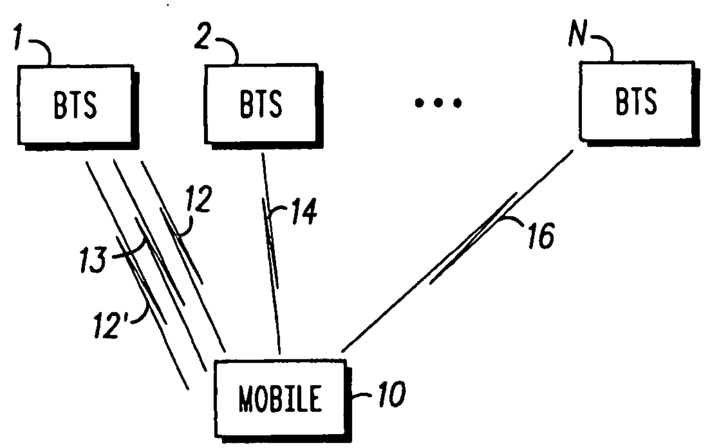
(54) Title: POWER CONTROL FOR REVERSE LINK CHANNELS



(57) Abstract: An arrangement for minimizing the number of power control bits required by a mobile unit (10) to simultaneously power control soft-handoff (DPCCH/DPDCH (12')) and non-soft handoff reverse link (HS=DPCCH) for supporting packet transfer over high speed downlink shared channel (HS-DSCH). A conventional DPCCH reverse link (12) and a high speed HS-DPCCH link (13) couple the mobile unit to the serving base station. The mobile unit also receives power control information for other reverse links coupling the mobile unit (10) to target base stations (2-N). Mobile unit (10) infers the power control information for the conventional link (DPCCH/DPDCH) from the serving base station from HS-DPCCH power control information. As a consequence, only one power control command or bit is sent by the serving base station.

WO 03/096572 A2

POWER CONTROL FOR REVERSE LINK CHANNELS

Background of the Invention

The present invention pertains to mobile communication systems and more particularly to power control of reverse links of a mobile unit during soft handoff and non-soft handoff conditions.

A mobile unit or mobile phone broadcasts on reverse link connections to many base stations while it is in operation. Each link between the mobile and a base station may be termed a reverse link. Some of the reverse links may be in soft handoff while others are not. A soft handoff is generally a connection between the mobile unit and two or more different base stations. The mobile unit communicates with multiple base stations when in soft-handoff.

Currently there are two ways to perform power control for a non-soft handoff reverse link. In the first method, the DPDCH, DPCCH and DPCCH-HS are power controlled based on power control bits from BTS's in the active set as per the or-of-downs rule. In this scenario, the HS-DPCCH is controlled from all the BTS's in the active set. This scheme suffers from the drawback, that when the serving BTS does not have the best uplink, the HS-DPCCH will be received with low reliability at the serving BTS. To overcome this problem, the HS-DPCCH should be transmitted at a much higher power (e.g. 15dB) compared to the no soft-handoff case. In the second method, the HS-DPCCH is only power controlled from the serving Node-B while the DPDCH and the DPCCH is power controlled from all of the Node-B's in the active set. This scheme requires two independent power control streams. This requires one additional power control bit to maintain 1500Hz power control rate. Alternatively, if the current 3GPP slot structure is to be maintained the power control rate can be reduced during soft-handoff. Both of these methods are inefficient.

Thus it would be highly desirable to have a method for power-controlling both the soft-handoff link (DPDCH and DPCCH)

and the non soft-handoff link (HS-DPCCH) using only one power control bit and without decreasing the power control rate of either channel.

Brief Description of the Drawings

FIG. 1 is a block diagram of a mobile unit's interconnection to a number of base stations via reverse links.

FIG. 2 is a flow chart of a method in accordance with the present invention executed by the serving base station in accordance with the present invention.

FIG. 3 is a flow chart depicting a method in accordance with the present invention executed by each of the non-serving base stations in accordance with the present invention.

FIG. 4 is a flow chart of a method executed by the mobile unit to determine power control information in accordance with the present invention.

FIG. 5 is a layout of a frame/subframe of a power control message with pilot bit insertion.

FIG. 6 is bit map layout of a power control message including the pilot bit insertion in accordance with the present invention.

Detailed Description of the Preferred Embodiment

A mobile in soft-handoff will have two or more reverse channels connecting the serving base station and target base stations . For a mobile station supporting high speed packet data channel there are three types of uplink channels: a) the uplink DPDCH (dedicated physical data channel)which is used to carry uplink data; b) the uplink DPCCH (dedicated physical control channel) which is used to carry control information generated by layer 1 which consists of pilot bits, transmit power control(TPC) command and transport format combination indicator (TFCI); and c) High Speed dedicated physical control channel (HS-DPCCH) which is used to carry ACK/NACK, Pilot bits and the channel quality indication (CQI) corresponding to the

high speed downlink shared channel. The mobile unit in soft-handoff can also be coupled, at the discretion of the network, to all other base stations capable of receiving its transmission via DPDCH 12′ and DPCCH 12.

FIG. 1 is a block diagram of a mobile unit 10 coupled to a number of base stations (BTS) 1-N for mobile telecommunications. Mobile or mobile unit 10 is coupled to base station 1 via reverse links 12 and 13. Reverse link 12 is a conventional dedicated physical control channel link (DPCCH) code multiplexed with dedicated physical data channel (DPDCH). Reverse link 13 also couples mobile unit 10 to base station 1. Reverse link 13 is a high speed-DPCCH link (HS-DPCCH).

When mobile unit 10 broadcasts on the conventional reverse link, DPCCH+DPDCH (12 and 12′), it transmits to base station 2 through N via links 14 and 16 and also to BTS 1 via DPCCH+DPDCH reverse link 12. For each transmission on the conventional reverse link DPCCH, each base station 1, 2-N will transmit power control information via the reverse links 12, 14 and 16 respectively to mobile 10.

Since base station 1 is the serving base station for mobile 10, it is also coupled to mobile 10 via the HS-DPCCH 13. The HS-DPCCH 13 includes a bit stream similar to that shown in FIG. 6 including the ACK/NACK, channel quality information (CQI) and pilot bits. Only the serving base station, BTS 1 is coupled to mobile unit 10 via a HS-DPCCH link. The other base stations 2-N are coupled via a conventional DPCCH+DPDCH link. Since the best forward link might not be the best reverse link, the DPCCH+DPDCH links to the serving base station may be insufficient to maintain adequate communications between mobile unit 10 and BTS-1 even though the DPDCH+DPCCH link is received with sufficient reliability by one or more BTS′s (2-N) in soft-handoff.

FIG. 2 is a flow chart depicting the operation by the serving base station, BTS 1. First, block 20 measures the signal to noise ratio or channel quality for the high speed reverse link 13 which couples mobile unit 10 and BTS 1. Such measurement of or channel quality (e.g. signal to noise ratio)

is presently performed and is known in the art. Next, block 30 determines whether the signal to noise ratio is greater than a predetermined threshold. The threshold may be adaptively set based upon a current error rate of reverse link 13.

If the signal to noise ratio is greater than the threshold, block 30 transfers control to block 40 via the YES path. Block 40 sends a message to mobile unit 10 via link 13 to decrease the power transmitted by mobile unit 10 on this reverse link. If the signal to noise ratio is less than or equal to the threshold, block 30 transfers control to block 50 via the NO path. Block 50 sends a message via link 13 to mobile 10 to increase the power mobile unit 10 is using to transmit on this reverse link. The process is then iterated at regular time intervals (e.g. every 1 slot or 0.67 msec. for UMTS WCDMA).

FIG. 3 is a flow chart performed by base stations 2 through N with the mobile unit 10 in soft handoff.

Block 60 measures the channel quality (e.g. signal to noise ratio) based on the pilot bits transmitted on the conventional dedicated physical control channel (DPCCH), reverse link 12. Next, block 70 determines whether the measured signal to noise ratio is greater than a predetermined threshold. Again, the threshold may be set adaptively by measuring the error rate of reverse link 12. If the signal to noise ratio is greater than this threshold, block 70 transfers control to block 80 via the YES path. Block 80 sends a message to the mobile unit 10 via link 14, for example, to decrease the power mobile unit 10 is using on channel 14.

If the signal to noise ratio is less than or equal to the threshold, block 70 transfers control to block 90 via the NO path. Block 90 sends a message via link 14, for example, to mobile unit 10 to increase power mobile unit 10 is using.

Similarly, each of the other N base stations, which are coupled to mobile unit 10, responds with a message including power control information, an increase power or decrease power instruction to mobile unit 10. This process is iterated at regular intervals for each non-serving BTS 2-N.

FIG. 4 is a flow chart of the methodology for power control as executed by the mobile unit 10. Block 100 receives the power control bit (PC HS-DPCCH)in the power control message via the high speed reverse link 13 of the serving base station 1.

Block 110 determines the ratio of the power (P HS-DPCCH)of the high speed channel 13 to the power (P DPCCH)of the conventional channel 12. Then block 110 determines whether this ratio is greater than alpha. Alpha is the ratio of the powers allocated to the HS-DPCCH and DPCCH when the link is not in a soft handoff. Alpha may be simulated 105 or calculated 115 based upon error probability of the reverse link 12 and 13. The calculation or simulation may be performed off-line.

If the power ratio, of the high speed reverse link (HS-DPCCH) 13 to the conventional reverse link (DPCCH) 12, determined by block 110 is less than or equal to alpha, then block 110 transfers control via the NO path to block 120. For the serving BTS 1, the power control of the conventional reverse link 12 is set equal to the power for the high speed link 13.

If the power ratio is greater than alpha, block 110 transfers control to block 130 via the YES path. Block 130 assigns an increase in the power used on the conventional link 12.

After block 120 or 130 has been performed, next block 140 applies the power bit (PC) received via downlink DPCCH (block 100)to the high speed link 13 (HS-DPCCH).

Next, block 150 performs an "or of downs" of the power bit (PC) of each of the non-serving base stations and the power bit of the conventional reverse link 12 from the serving base station, BTS 1 based on the outcome of block 110 through 130. Block 150 then performs a logical OR function of each of these bits. An "or of downs" means that, if any power bit of any base station is set to lower the power for mobile unit 10, then the power of the DPCCH and the corresponding DPDCH is decreased. Conversely, if all the power bits for all the base stations indicate to increase the power, only then is the

power of the DPCCH and the corresponding DPDCH for the mobile unit 10 increased. Block 160 then applies the power control decision resulting from "or-of-downs" rule to the DPCCH and the corresponding DPDCH.

In this way, both the high speed channel, HS_DPCCH 13, and the conventional channel(DPCCH+DPDCH) 12 power control are determined by mobile unit 10 after receiving one power control command from the serving base station and one power control command from each of the BTS's 2-N.

As a result, power required to send power control bits is cut in half and the power control is calculated on each message received instead of every other message received due to multiplexing. With half the power being used by the serving base station, power control information for both reverse channels 12 and 13 is inferred and processed by mobile unit 10.

Pilot Bit Insertion in the HS-DPCCH field

FIG. 5 is a layout diagram of subframe and frame of the HS-DPCCH link. The in band insertion of special pilot bits into the HS-DPCCH is done so that accurate channel estimation can be derived for decoding the information sent on the HS-DPCCH. The HS-DPCCH includes an Ack/Nack (acknowledge or non acknowledge) field; channel quality indication (CQI) field in the next position in the subframe; and the pilot bits inserted at the end of the subframe as shown in FIG. 5. The Ack/Nack field; the channel quality indication, which is a measure of the quality of the channel (e.g. signal to noise ratio (SNR)); and the HS-pilot bits comprise a subframe. The subframe may be 2 ms in duration for UMTS supporting High speed downlink shared channel (HS-DSCH). There are preferably 5 subframes in one transmitted radio frame which is approximately 10 ms in duration in a preferred embodiment of the invention.

FIG. 6 depicts an example of a bit map layout or data structure of a subframe for the HS-DPCCH link modified in

accordance with the present invention. The subframe layout includes the ACK/NACK field (10 bits); 2 pilot bits; CQI 15 bits; and 3 pilot bits. The pilot bits are dispersed throughout the subframe to provide a more reliable average measurement of the phase of the bits for demodulation. Typically, BPSK or QPSK modulation/demodulation is used.

Although the preferred embodiment of the invention has been illustrated, and that form described in detail, it will be readily apparent to those skilled in the art that various modifications may be made therein without departing from the spirit of the present invention or from the scope of the appended claims.

CLAIMS

1. A method for inferring power control information by a mobile unit from a serving base station, the method comprising the steps of:

receiving by the mobile unit a plurality of messages from the serving base station on a first reverse link, each of the plurality of messages including power control information;

coupling the mobile unit to the serving base station via a second reverse link;

determining whether a ratio of power of the first reverse link to power of the second reverse link is greater than a first predetermined threshold; and

if the ratio is not greater than the first predetermined threshold, setting the power control information of the second reverse link equal to the power control information of the first reverse link.

2. The method for inferring power control information as claimed in claim 1, wherein there is further included a step of if the ratio is greater than the predetermined threshold, increasing setting the power control information for the second reverse link.

3. The method for inferring power control information as claimed in claim 1, wherein there is further included a step of simulating the predetermined threshold based upon the error probability of the first and second reverse links.

4. The method for inferring power control information as claimed in claim 1, wherein there is further included the step of calculating the first predetermined threshold based upon an error probability of the first and second reverse links.

5. The method for inferring power control information as claimed in claim 1, wherein the step of receiving includes the

step of applying the power control information by the mobile unit to the first reverse link.

6. The method for inferring power control information as claimed in claim 1, wherein:

at least one non-serving base station coupled to the mobile unit via at least one third reverse link for receiving power control information; and

oring of downs with the power control information of the second reverse link and the at least one third reverse link.

7. The method for inferring power control information as claimed in claim 6, wherein the step of oring of downs includes the step of logically oring the power control information of the second reverse link and the at least one third reverse link, such that if any of the power control information of the second reverse link or at least one third reverse link indicate power down, then sending power down message to the mobile unit.

8. The method for inferring power control information as claimed in claim 7, wherein there is further included a step of applying by the mobile unit the power down or a power up to the second reverse link.

9. The method for inferring power control information as claimed in claim 1, wherein there is further included a step of iterating the steps of claims 1 through 8.

10. The method for inferring power control information as claimed in claim 1, wherein there is further included a step of measuring by the serving base station a signal to noise ratio for the first reverse link.

11. The method for inferring power control information as claimed in claim 10, wherein there is further included the step of determining whether the signal to noise ratio is greater than a second predetermined threshold.

12. The method for inferring power control information as claimed in claim 11, wherein:

if the signal to noise ratio is greater than the second predetermined threshold than sending by the serving base station a message to the mobile unit to decrease power; and

if the signal to noise ratio is less than or equal to the second predetermined threshold, than sending by the serving base station a message to the mobile unit to increase power.

13. The method for inferring power control information as claimed in claim 1, wherein:

there is further included a plurality of non-serving base stations, each non-serving base station coupled to the mobile unit via a third reverse link; and

there is further included a step of measuring by each of the plurality of non-serving base stations a signal to noise ratio for each third reverse link.

14. The method for inferring power control information as claimed in claim 13, wherein there is further included the step of determining by each of the plurality of non-serving base stations whether the signal to noise ratio is greater than a second predetermined threshold.

15. The method for inferring power control information as claimed in claim 14, wherein:

if the signal to noise ratio is greater than the second predetermined threshold, then sending by the non-serving base station to the mobile unit a decreased power message; and

if the signal to noise ratio is less than or equal to the second predetermined threshold, then sending by the non-serving base station a message to the mobile unit to increase power.

16. A method for transmitting power information between a base station and a mobile unit, the mobile unit being coupled to the base station by a first reverse link and a second reverse link, the method for transmitting power information comprising the steps of:

receiving the power information by the mobile unit on the first reverse link;

determining whether a ratio of power of the first reverse link to a power of the second reverse link is greater than a predetermined threshold;

if the ratio is not greater than the predetermined threshold, setting the power information for the second reverse link equal to the power information of the first reverse link; and

if the ratio is greater than the predetermined threshold, increasing the power information for the second reverse link.

17. The method for transmitting power information as claimed in claim 16, wherein there is further included a step of simulating the predetermined threshold based upon an error probability of the first and second reverse links.

18. The method for transmitting power information as claimed in claim 16, wherein there is further included a step of calculating the predetermined threshold based upon an error probability of the first and second reverse links.

19. A pilot bit data structure for a frame transmitted on a high speed reverse link between a mobile unit and a base station comprising:

an acknowledge/non-acknowledge field;

a first pilot bit field;

a channel quality indication field; and

a second pilot bit field.

20. The pilot bit data structure as claimed in claim 19, wherein:

the acknowledge/non-acknowledge field includes ten bits;

the first pilot bit field includes two bits;

the channel quality indication field includes fifteen bits; and

the second pilot bit field includes three bits.

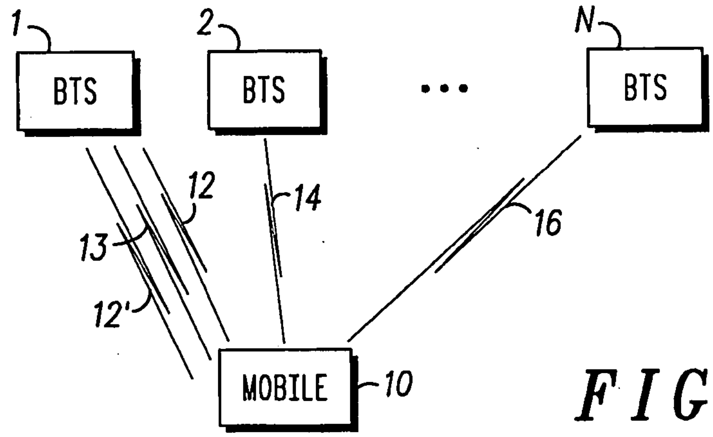


FIG. 1

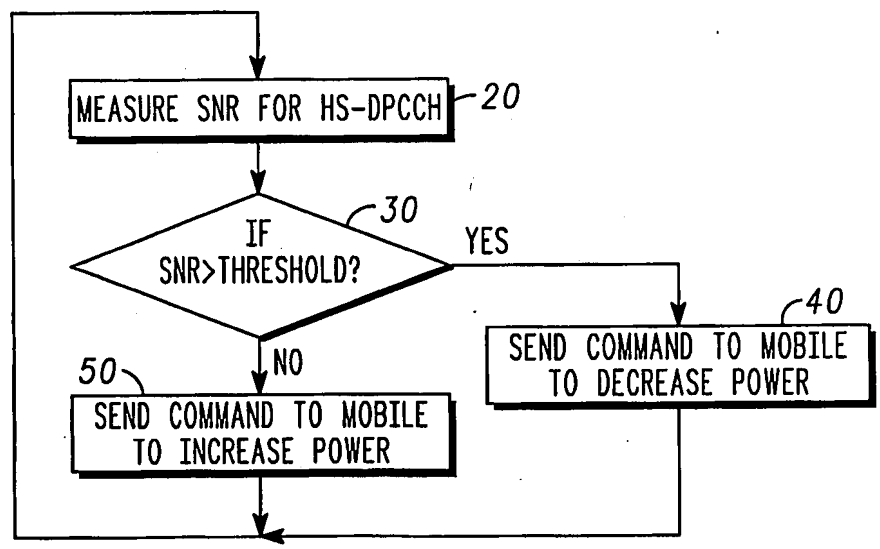


FIG. 2

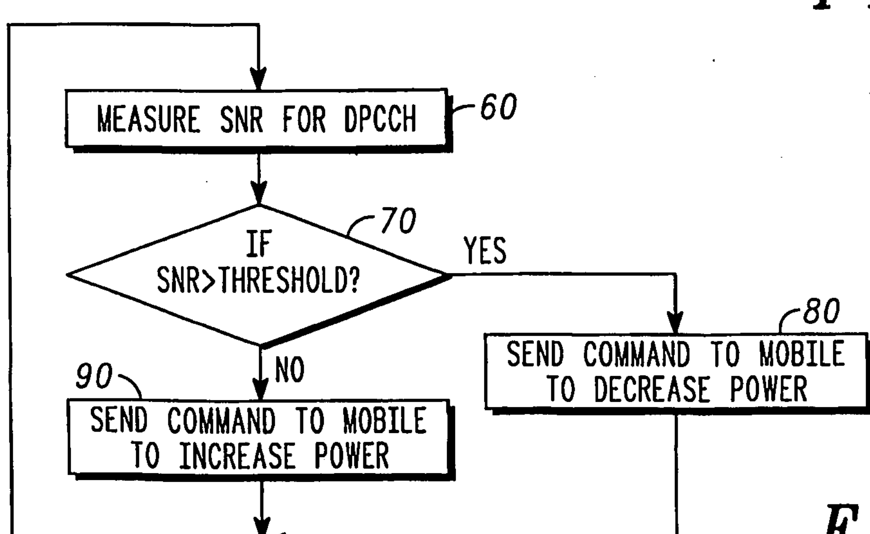


FIG. 3

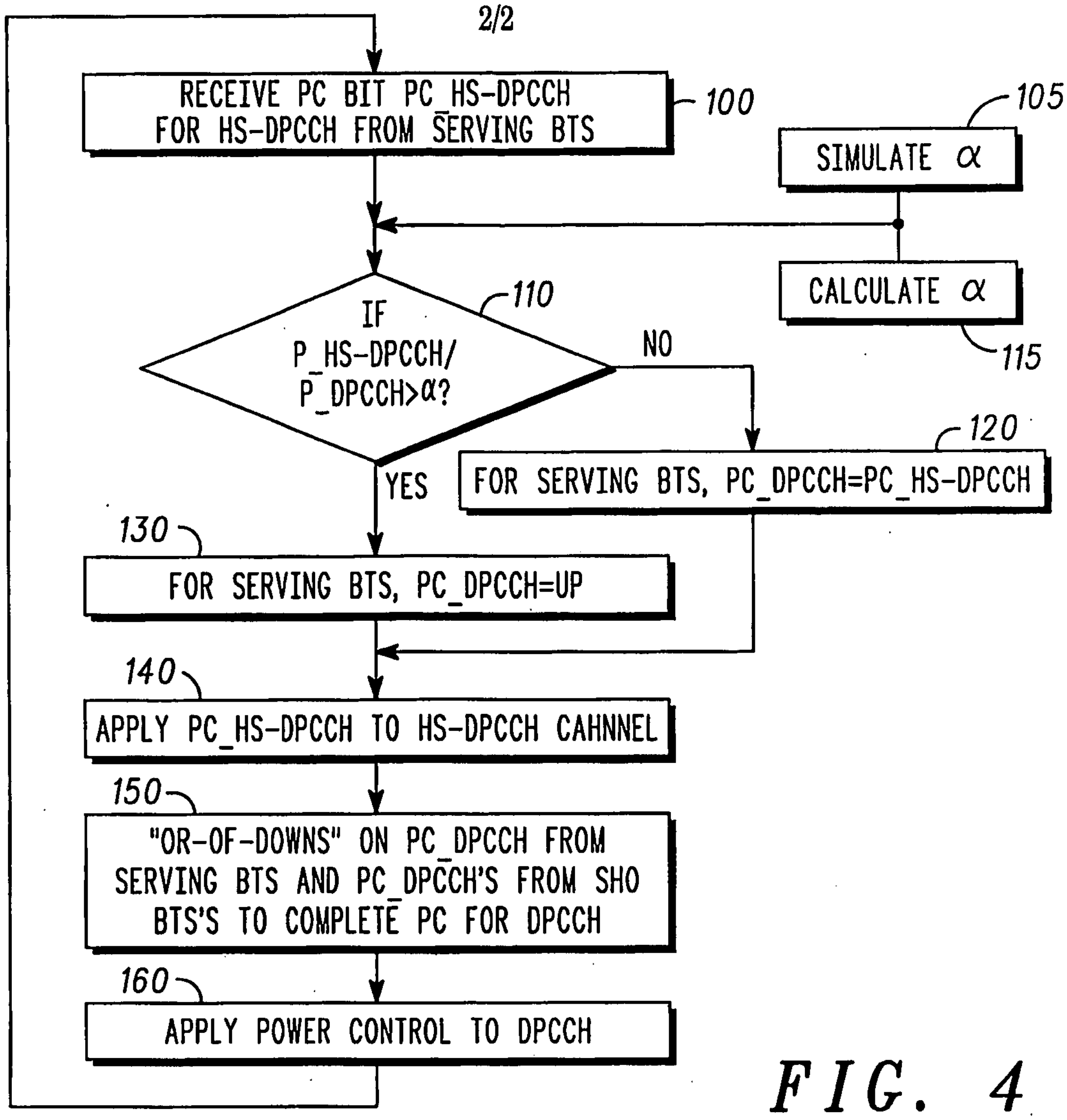

RECEIVE PC BIT PC_HS-DPCCH FOR HS-DPCCH FROM SERVING BTS
100
105
SIMULATE α
CALCULATE α
115
IF P_HS-DPCCH/ P_DPCCH>α?
110
NO
120
FOR SERVING BTS, PC_DPCCH=PC_HS-DPCCH
YES
130
FOR SERVING BTS, PC_DPCCH=UP
140
APPLY PC_HS-DPCCH TO HS-DPCCH CAHNNEL
150
"OR-OF-DOWNS" ON PC_DPCCH FROM SERVING BTS AND PC_DPCCH'S FROM SHO BTS'S TO COMPLETE PC FOR DPCCH
160
APPLY POWER CONTROL TO DPCCH

FIG. 4

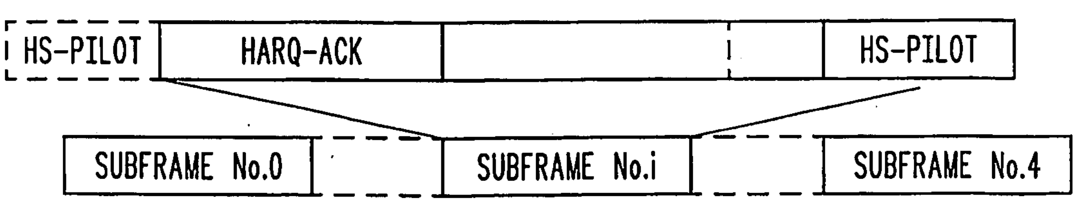
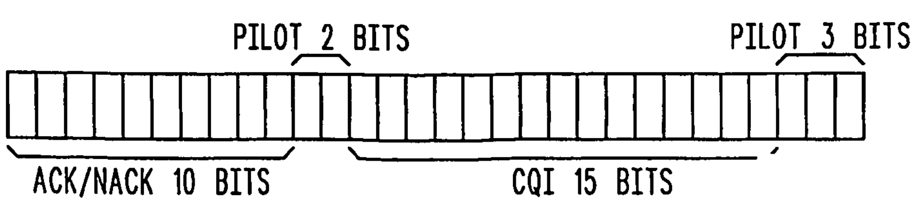

HS-PILOT
HARQ-ACK
HS-PILOT
SUBFRAME No.0
SUBFRAME No.i
SUBFRAME No.4

FIG. 5


PILOT 2 BITS
PILOT 3 BITS
ACK/NACK 10 BITS
CQI 15 BITS